Guidelines for the Selection and Implementation of Sustainable Sanitation Systems for the Reconstruction in Aceh and Nias

– Draft –

For Government and International Agencies and Organizations engaged in housing projects in Aceh and Nias

Prepared by: GTZ in cooperation with Oxfam, IFRC and UNICEF

Banda Aceh, February 2007

Foreword

These guidelines have been produced in response to an urgent need for practical answers. The challenges to sustainable sanitation in Aceh are many although it has now been shown that with serious commitment, realistic solutions do exist. The guidelines synthesize all the major issues so the various levels of planning, design and implementation may be carried out with reference to one document.

The guidelines are specifically for the social and physical conditions prevailing in tsunami-affected Aceh under reconstruction. They provide a guide for local government, non-governmental organizations and international donors to more easily determine appropriate technology options in sanitation in Aceh.

The draft has been compiled by GTZ in cooperation with Oxfam, IFRC and UNICEF with reference to field projects implemented by ATLAS Logistique, French Red Cross, GTZ and USAID. Research on the current condition of sanitation in Aceh plus the most pressing challenges in the field, as well as practical solutions for improving sanitation standards have been compiled in these Draft Guidelines.

Indonesian National Standards and Provincial Building Codes have been examined and those most relevant have been highlighted and explained. It is expected this will assist implementing organizations in the development of sustainable sanitation solutions, which comply with Government Regulations and Standards.

A public consultation process with national and international organizations and agencies involved in WATSAN programs was begun in November 2006 with the initial distribution of the Draft Guidelines. Feedback and input from sanitation players has been considered for this version.

This draft is the working document for a major sanitation seminar to be held in February 2007. It should serve as a basis for seminar discussions as well as a practical reference on the main issues. It will also be the basis for a more definitive document -integrating results from working groups as well as more examples of successfully implemented sanitation projects - to be published soon after the seminar.

The Guidelines are a ‘living’ document, it is hoped more examples of sustainable sanitation and drainage will be forthcoming for inclusion in future printings.

Widespread adoption of guidelines will better facilitate cooperation and coordination between players in sanitation and drainage by standardizing major issues.

The purpose of the Guidelines is to facilitate rapid, and substantial, improvements in the planning, design and implementation of systems for sewage and wastewater treatment in an attempt to minimize future negative health impacts in returning communities.

CONTENT

I INTRODUCTION

1 General Issues on Sanitation

"In many countries there exists a high prevalence of water and sanitation related diseases, causing many people, children in particular, to fall ill or even die. Improved hygiene practices are essential if transmission routes of water and sanitation related diseases are to be cut. Whereas appropriate hygiene education can bring about the intention to change hygiene behaviour, for most hygiene behaviours *appropriate water and sanitation facilities are needed to allow people to transform intention to change into real change."* (*UNICEF Programme Division Guidelines Series, Towards Better Programming: A Manual on School Sanitation and Hygiene, 1998*)

Sanitation is the means of collecting, treating and disposing of excreta and liquid wastes in a hygienic way so as not to endanger the health of the individuals and the community as a whole. Hygienic treatment and disposal (or recycling) of human wastes that does not endanger health or contaminate the local environment are always the underlying objectives of sanitation programs.

Human excreta may contain four types of pathogens, namely, eggs of helminths, protozoa, bacteria and viruses. Helminths and protozoa are not considered a huge risk as they are relatively large, and are often removed effectively though physical filtration in the soil. Bacteria and viruses are much smaller, therefore the percolating effluent from sanitation systems can transport bacteria and viruses into the groundwater and these organisms may be ingested and cause infection (e.g. diarrhea).

As a consequence of poor sanitation (and inappropriate drainage) local water sources are polluted with pathogens rendering them unsafe for cooking or drinking. It is fundamental to sustainable development that local water sources be protected from contamination. It is also vital that due care is taken to minimize the negative downstream effects of wastewater treatment and/or disposal.

Vector-borne Diseases

According to the W.H.O. Dengue Fever is the fastest growing vector-borne disease in the world. Standard sanitation and drainage systems in Indonesia provide ideal breeding habitat for the dengue mosquito. Dengue fever kills thousands of Indonesians annually and it is becoming worse every year. Tragically, a great deal of *new* breeding habitat has already been created by inappropriate drainage and sanitation programs, being carried out as part of the reconstruction process in Aceh.

Diarrhea, a major killer of young children, caused by water contaminated with human wastes. Encephalitis and Elephantitus are vector-borne diseases. Typhoid and cholera are spread by flies which breed in moist, rotting organic matter in drains and rubbish piles.

According to the WHO's 'Global Framework for Vector Control' our main weapon against these diseases is better environmental management, which includes better sanitation and drainage.

2 The Aceh Context

Sanitation before the Tsunami and its problems

Aceh suffered an armed conflict for nearly 30years, one result of which was that community infrastructure, including sanitation systems were generally of a very low standard. Although there is a fair understanding that poor sanitation affects the community, experience during socialization programs suggests there is a lack of awareness that better alternatives do exist. This may be the main reason why it ranks so low in people's minds.

Pre-Tsunami toilets and septic tanks were often not used in rural communities, instead the population defecated outside housing areas e.g. in paddy fields, rivers and beaches. The post-tsunami reconstruction program includes upgrading living conditions including installation of appropriate and sustainable sanitation facilities. Bringing sustainable sanitation into densely populated settlements with high water tables and frequent flooding is extremely challenging, however, sustainable sanitation is a prerequisite for achieving the Millennium Development Goals and as such is deserving of stronger commitments from Government, Aid and Development agencies.

Current State of Sanitation in Reconstruction in Aceh

A random sampling of reconstruction projects shows sanitation and drainage standards, in general, remain very low. Current installations are contaminating ground and surface waters and they are also creating extensive breeding habitat for disease vectors. Preventable diseases like Dengue Fever, typhoid, encephalitis, chronic skin conditions and gastro-intestinal illnesses are likely to become entrenched in resettled communities as a direct result of poor sanitation and drainage installations.

Nevertheless, there is a perceptible trend across the reconstruction community, towards finding more sustainable solutions. What fraction of the reconstruction program receives reasonable standards of sanitation and drainage will ultimately speak of the success or failure of current efforts.

Opportunities in Reconstruction

The massive scale of reconstruction in Aceh offers an unprecedented opportunity to the international Aid and Development communities to implement more sustainable sanitation and drainage on a broad scale - thereby safeguarding the health and well-being of many thousands of families already traumatized by years of armed conflict and the tsunami.

When medium and long-term effects are factored in, cost benefit analysis shows the costs of poor sanitation to be unacceptably high. Conversely, the benefits of better sanitation are substantial, more than offsetting the initial investment. Scenario building comparing ‘business as usual’ to more sustainable solutions demonstrates predictable health and economic impacts, depending on choices that are being made now. No plausible, positive scenarios arise from the ‘business as usual’ model. Unfortunately, the health effects of installing poor sanitation systems in a moist tropical environment are extremely predictable.

There are few international technical standards for sustainable sanitation and drainage, for developing countries, in the wet tropics. If field results can be improved, the Aid and Development communities will benefit significantly from technical advances made in Aceh. By creating a large-scale model, Indonesia as a whole will benefit from the implementation of better systems in Aceh.

The Millennium Development Goals (MDG’s) can be met if sanitation and drainage are prioritized alongside the provision of clean water.

Allocation of necessary funds – a responsibility of local authorities, international agencies and NGOs

Initial investments in planning, development/design and careful implementation of appropriate sanitation systems, will pay dividends in the short to mid-term:

- By reducing very significant (but currently externalized) costs to the community
- By reducing health costs as a result of poor sanitation
- By increasing opportunities for sustainable economic development

3 The Challenges

Installing appropriate sanitation and drainage systems in low-lying coastal communities in Aceh presents special technical, institutional and environmental challenges.

Water tables in many resettlement communities are very high, typically, less than one meter after (frequent) rains. Water tables higher than 40cm are not uncommon creating serious construction and treatment challenges.

The **flat coastal topography** provides very few opportunities for gravity flows in drainage channels or centralized piping networks. That is, communal or centralized systems are usually not an option.

Soil conditions vary from site to site. The tsunami had major impacts on low-lying topography – by scouring and deposition. Soil types range from gravels to sands to clay loams to sticky clays. Soils in low-lying areas remain waterlogged after rains. Some soils are free draining while others have slow percolation rates.

In many areas, water sources are **shallow wells** requiring only a bucket. Poor sanitation and drainage systems contaminate these local water supplies. Opportunities to use local water resources are lost, forcing the use of deep or distant water sources, which must then be supported by their attendant infrastructure i.e. pumps and piping.

The **sheer size of the reconstruction program** results in problems of quality control, availability of skilled labour, proper supervision and monitoring.

In very high water tables excavations are continually flooded. This technical difficulty, compounded by minimal quality control in the field, rules out most conventional approaches to installing septic tanks. Building *waterproof* concrete tanks on-site has proven extremely difficult to impossible. **Quality control at every level** of sanitation projects has often failed to ensure installations are of an adequate standard.

Land availability is an issue when planning for centralized systems eg treatment wetlands. Most land in and around settlements is privately owned. If land is required for public facilities, it must usually, but not always, be purchased. **Small house plots** are an issue for the installation of on-site systems, however, it has been demonstrated that even on very small plots, treatment systems can be made to fit.

Appropriate Government Regulations and Standards do exist although **official inspection and enforcement programs have not been implemented**. In the absence of direction or sanctions from Government, implementing organizations must accept their responsibility to make serious efforts to comply.

II RECOMMENDATIONS FOR SANITATION IN ACEH

1 Basic Principles

Sewage and wastewater treatment = Nutrient Cycling
Being in the wet tropics, Aceh experiences a nutrient cycle quite different to temperate climates. As wastewater treatment may be described as a form of nutrient cycling, this fact has major implications for sewage and wastewater treatment in Aceh. Effective sanitation systems in Aceh will need to employ nutrient harvesting as a treatment strategy.

Tropical Nutrient Cycle versus Temperate Nutrient Cycle
Nutrients cycle differently in the tropics in two very important ways, which have profound implications for wastewater treatment:

1. Nutrients cycle more rapidly, and continuously, in the tropics because of consistently higher temperatures. This means smaller treatment systems in the tropics can treat wastewater to the same standard as larger systems in cold climates.
2. In the wet tropics, nature stores nutrients in the biomass i.e. trees and plants. In temperate climates, nutrients are stored in the soils. When a forest is cut in Europe, soils remain fertile for a very long time. When a forest is cut in the tropics, because of warm temperatures and rains, fertility is lost in a short time. In the tropics, removing nutrients from wastewater benefits from the use of nutrient harvesting plant systems.

In order to protect public health and to avoid groundwater contamination and downstream health risks for the population - for this and future generations - all sanitation installations should adhere to basic principles of sustainability.

These Guidelines are based on **three Guiding Principles**:

1. **No *untreated* wastewater may be released into public drains**
2. **All sanitation systems must have primary *and secondary* treatment as a minimum**
3. **Septic tanks must be watertight in service**

2 Suitable Sanitation Systems in Aceh

Several systems are introduced in these guidelines. Options for on-site and communal sanitation in Aceh are not limited to these systems however *those listed have been demonstrated in the field.* Implementers are encouraged to develop their own systems adapted specifically to suit each individual reconstruction project.

The Guidelines offer solutions for:

- **Individual on-site treatment and disposal** – *no-slope,* low-lying housing projects
- **Small communal treatment and disposal** – clustered housing, schools, hospitals, shared facilities
- **Communal treatment and disposal** – schools, hospitals, shared facilities, housing projects with natural slope for gravity flows

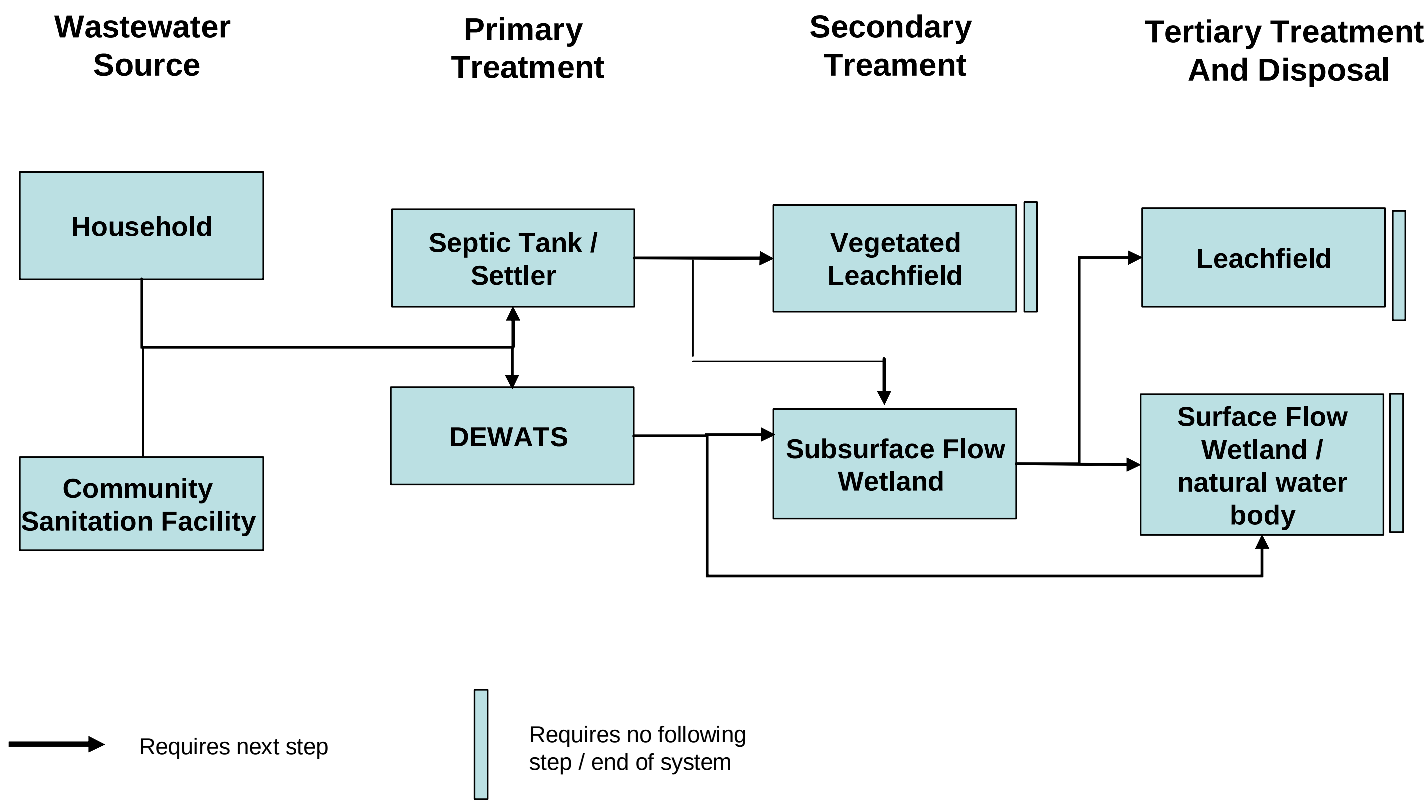
Basic components of treatment systems in this document are:

- Waterproof septic tank - *primary* treatment
- Vegetated leachfield and/or **sub**surface flow wetland - *secondary* treatment
- Vegetated leachfield and/or surface flow wetland - *tertiary* treatment & final *disposal*
- Communal septic tank/s, biogas digester and/or baffled reactor – *primary* and *secondary* treatment

The recommended systems are suitable for high groundwater tables they require minimal maintenance therefore operating costs are very low. On-site systems can be installed with locally available materials, common skills and basic training.

Basic, on-site treatment systems cost 5mil - 7mil Indonesian Rupiah.

Overview


Wastewater Source
Primary Treatment
Secondary Treament
Tertiary Treatment And Disposal
Household
Community Sanitation Facility
Septic Tank / Settler
DEWATS
Vegetated Leachfield
Subsurface Flow Wetland
Leachfield
Surface Flow Wetland / natural water body
Requires next step
Requires no following step / end of system

3 Short Description of Recommended Systems

Septic Tank

“Septic tank means a *watertight* receptacle constructed to promote separation of solid and liquid components of wastewater to provide limited digestion of organic matter, to store solids, and to allow clarified liquid to discharge for further treatment and disposal in a soil absorption system.” (Florida Department of Environmental Protection)

A functional septic tank is watertight. Open-ended ‘septic tanks’ without a sealed floor are more appropriately described as ‘soak-pits’. They should not be described as septic tanks and do not provide appropriate treatment of wastes.

Septic tanks must be of appropriately high quality. Materials, manufacture, configuration and installation must ensure a long, trouble-free service life – these Guidelines propose a minimum of 10years.

Even minor leakage from septic tanks is not acceptable. This point must be emphasized at all levels. A small leak will allow most, or all, household wastewater to leach directly into the groundwaters.

SEPTIC TANK LEAKS - *‘Even a small leak empties the tank’*

If a septic tank leaks only 350ml/min it equals 21liters/hr. Over one day, the tank will leak 504liters.

If total wastewater from one house is 500liters/day, over 24hrs, a leak of 350ml/min means *all* household sewage and wastewater will leach into groundwater below the septic tank.

Even a small leak of 350mil/min means *no* wastewater will reach the secondary systems for proper treatment and disposal.

Why is it so important that septic tanks are watertight?
A leaking septic tank means there is (almost) no primary and no secondary treatment.

- Human wastes are the main source of groundwater contamination by pathogens. Leaking septic tanks contaminate the environment.
- Biological treatment processes depend on water. A dry septic tank does not provide primary treatment.
- Secondary treatment cannot take place unless wastewater reaches the secondary systems. Flows are small - maximum 3liters/minute or 200l/hr during peak periods. Even small leaks in septic tanks will stop wastewater reaching secondary treatment systems.

Recommendation
To ensure they are guaranteed watertight in service, it is strongly recommended to install prefabricated septic tanks.

Thousands of 'septic tanks' have been built on-site. Very few tanks inspected have been watertight, the majority, by far, leak or have no floor. It is extremely difficult, in the context of reconstruction, to build watertight septic tanks on-site.

Costs

Prefabricated septic tanks cost 1.2mil to 5.5mil Indonesian Rupiah.

Vegetated Leachfields

A vegetated leachfield is an open system in which primary-treated wastewater is evenly distributed through a horizontal, perforated pipe laid in a gravel bed. The gravel bed is covered with sand then densely planted with fast-growing plants, which 'harvest' nutrients, the main pollutants found in ground and surface waters. Horizontal flows in the leachfield distribute wastewater over a large area for treatment by roots and microbes in the gravel.

The standard of treatment by leachfields is hard to measure empirically. It is however clear that horizontal flows, which distribute wastewater evenly over a large area, achieve a much better result than vertical soak-pits. In the context of reconstruction, it is considered an acceptable, minimum standard for secondary treatment and disposal.

A major advantage of leachfields is that they stop the need to dump wastewater into public drains. Nutrient-rich wastewater stagnates in drains with no slope maintaining mosquito and fly populations thereby ensuring vector-borne diseases will again plague returning communities.

Elevated or mounded leachfields for very high water tables

For effective treatment leachfields depend on an unsaturated medium through which the wastewater percolates. In very high water tables <1m vegetated leachfields should be installed in a mound, above ground – *this can only be done when waste outlets from houses are high enough.*

Costs

Vegetated leachfields x 10sq/m cost 3 mil – 4 mil Indonesian Rupiah to install.

Individual Vegetated Leachfield for standard reconstruction house (5 inhabitants)

The primary treatment, including separation of liquid and solid wastes, takes place in an individual watertight septic tank. From the septic tank, wastewater flows to a vegetated leachfield of 10sq/m. The shape of each leachfield is flexible and can be adapted to fit even small house plots. A properly designed and installed vegetated leachfield provides secondary treatment and final disposal for all household sewage and wastewater.

Communal Vegetated Leachfield for clustered housing (2–10 houses)

Sufficient slope for gravity flows and an available space for the leachfield are required for a shared or communal leachfield.

Primary treatment including separation of liquid and solid wastes takes place in an individual or shared septic tank. Outflows from individual septic tanks must be transported through a gravity-flow piping system to a communal, vegetated leachfield and/or subsurface flow wetland. The size of the leachfield and/or wetland depends on the number of connected households - approximately 10 sq/m per household. The layout of communal leachfields and wetlands is flexible and can be adapted to site conditions.

Subsurface Flow (SSF) Wetland

A more effective secondary treatment system consists of a watertight **subsurface flow wetland.** Properly designed and installed subsurface flow wetlands can meet international standards for wastewater treatment.

A subsurface flow wetland is a closed system with a gravel bed and a waterproof lining. The gravel bed is densely planted with nutrient harvesting plants – similar to the vegetated leachfield. Pre-treated wastewater from the septic tank flows into a subsurface flow wetland where it slowly percolates through the gravel to the outlet at the other end. Due to the watertight lining wastewater is retained in the system for a given length of time (Hydraulic Retention Time, HRT) to be treated by microbes and the roots of plants. Outflows from the wetland should be disposed of in a vegetated leachfield or into natural ponds or wetlands.

Individual subsurface flow wetland system for a standard reconstruction house (5 inhabitants)
Primary treatment and separation of liquid and solid wastes takes place in an individual septic tank. From the septic tank wastewater flows to a subsurface flow (ssf) wetland of minimum 4sq/m size if combined with a 6sq/m vegetated leachfield. A ssf wetland of 8 sq/m may be combined with disposal into a soak-pit, natural ponds or wetlands.
A ssf wetland must be watertight and the lining material must be very durable.

Communal subsurface flow wetland for clustered housing (2 – 20 houses)

Primary treatment and separation of liquid and solid wastes takes place in an individual or shared septic tank. Outflows from individual septic tanks must be transported through a gravity-flow piping system to a communal ssf wetland. The minimum size per household is 4 sq/m if the communal subsurface flow wetland is combined with a communal leachfield. A minimum 8sq/m ssf wetland per house should be installed if the outflow is disposed of into natural ponds or wetlands.

Costs
Subsurface flow wetlands cost 800.000 – 1mil Indonesian Rupiah per sq/m to install.

DEWATS – Communal Wastewater Treatment System

The DEWATS system is a compact, modular treatment plant, consisting of various combinations of biogas digester, anaerobic baffled reactor, subsurface flow wetlands and/or vegetated leachfields.

The treatment system is suitable where many people use shared facilities such as schools or hospitals or communal sanitation centres (MCKs). It can also be installed as communal treatment system for a minimum of 20 houses in dense housing settlements where sufficient slope for collection and transportation of household wastewater is available.

The system has the advantage that most of the structures can be built underground, which makes it suitable for crowded areas where land is not easily available. Treatment efficiency is high. It is a robust system requiring only minimal maintenance.

The DEWATS system is being installed in 15 locations in Aceh.

For further information, please contact:
www.borda-sea.org

III TECHNICAL STANDARDS FOR SANITATION SYSTEMS

1 Technical Notes and relevant Indonesian National Standards (SNI)

Household wastewater is herein divided into two categories defined as:

- Black water – sewage a combination of faeces, urine and water
- Grey water – household wastewater from bathroom, laundry and kitchen

Technical Assumption

In the context of reconstruction in Aceh, 1PE (person equivalent) is assumed to be 100 liters/day.

Total wastewater production for a standard reconstruction house:

- 1PE (1 person) 20liters/day black water – Total 5PE = 100liters/day black water
- 1PE (1 person) 80liters/day grey water – Total 5PE = 400liters/day grey water

For a standard reconstruction house the total production of wastewater is **500liters/day.**

2 Standards for Septic Tanks

The following recommendations are based on the P.U. Building Code and National Standard for Septic Tank issued by *Badan Standarisasi Nasional Indonesia* code SNI 03-2398-2000 (Planning Guideline for Designing Septic Tank - *Tata Cara Perencanaan Tangki Septik)*.

The proposed Minimum Hydraulic Retention Time in Septic Tanks is 1,5 days.

Design Recommendations

CHAMBERS

- One, two or three chamber designs are options. The more chambers the higher the treatment efficiency as more solids are settled out.
- In case of a two-chamber tank: First chamber size = 2/3 of total
- In case of a three chamber tank: First chamber size = 1/2 of total

SHAPE

- Shorter, wider tanks are easier to install in high groundwater tables. Taller/deeper tanks are more difficult to install in flooded excavations and they suffer from increased risk of flotation if not held down.

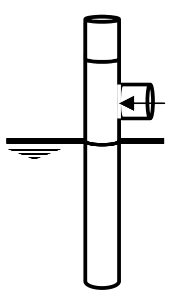
CAPACITY and VOLUME

- The volume of the septic tank includes the liquid volume plus free space above the static water level to allow for surge capacity. These guidelines propose as a rule of thumb that approximately 15% of the tank's volume remains free space.
  The SNI states for a standard rectangular septic tank 30 cm free space above the static water level is required.

- For a septic tank with mixed black and grey water (500l/day) the minimum liquid capacity of the tank should be 1000 litres. This assumption is based on a HRT of 1,5 days and a desludging period of 2 years. Less tank capacity requires more frequent desludging.

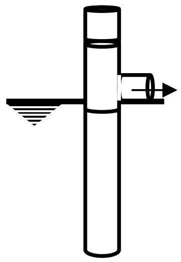
SEPTIC TANK INLET & OUTLET PIPES

The inlet and outlet ports of the tank are generally equipped with sanitary tees with pipes extending above and below the scum layer.



The inlet T-joint dissipates the energy of the incoming flow and deflects it downwards. *The vertical leg of the tee extends below the liquid surface well into the clear space below the scum layer.* This prevents disturbance of the floating scum layer and reduces disruptive turbulence caused by incoming flows. The inlet T-join device also prevents short-circuiting of flows across the water surface directly to the outlet.

The upper leg of the inlet should extend minimum 15 cm above the liquid surface in order to prevent floating scum from backing up into, and possibly clogging, the main inlet pipe. The open top of the inlet tee also allows venting of gases.



The outlet T-joint is installed to retain the scum layer within the tank.

The lower leg of the outlet should extend minimum 20 cm below the liquid surface.

The SNI states that normally the outlet port is installed 5 to 10 cm lower than the inlet port – however, lowering the outlet port automatically lowers the secondary treatment system by the same amount. In the context of Aceh this small loss of height may be important. Where slopes are minimal, outlet ports may be installed at the same level as inlet ports.

Inlet and outlet pipes should be of 100mm (3") diameter.

INSPECTION PORTS and VENTILATION

- Manholes and inspection ports should be installed for every chamber of a septic tank.
- Ventilation pipes should be installed for every chamber in the septic tank

LOCATION of the TANK

- The minimum distance between a watertight septic tank and shallow well is according to SNI 1,5 m.
- Access for desludging should be ensured, where possible, in the front of the house near the road.

MATERIALS

These guidelines propose that a septic tank should be durable in service for a minimum of 20 years. Fiberglass, concrete and plastic are sufficiently durable materials. As mentioned above, prefabricated tanks are strongly recommended above tanks constructed on-site.

- Septic tanks, especially plastic/fibreglass, risk floating if emptied when water tables are very high. If deemed necessary by the implementing agency a concrete burden may be placed on top of the tank to stop it floating. Rule of thumb: 1000litre fibreglass tank requires .45cu/m concrete burden.

- Plastic tanks require structural support against crushing. A collar made out of concrete and/or bricks can stop the tank floating and protect it from crushing.

- In the context of reconstruction watertight concrete tanks, *built on site*, have proven extremely difficult to guarantee. Although they incur extra transport and handling costs, prefabricated concrete tanks are recommended above tanks built on-site.

SLUDGE DISPOSAL

- Septic tank sludge must be pumped-out periodically every 1-4 years according to inflows and the design of septic tank - typically, when the tanks are one-third to one-half full of sludge and scum.
- Desludge (pump-out) only the first chamber of the septic tank or settler or sedimentation chamber, not the whole tank
- Stir up the tank bottom before pumping-out

- Do not pump out all the sludge. Leave some sludge at the bottom (about 10%) as 'seed' for the next cycle of operation.
- In areas with very high water tables, desludging should not take place during the rainy season in order to avoid the risk of floating.
- Sludge from septic tanks is pathogenic and harmful to the environment - it must not be disposed of directly to the environment. Sludge should be taken to a sludge-treatment facility.

Sludge treatment facility - IPLT Banda Aceh

A sludge treatment plant (*Instalasi Pengolahan Lumpur Tinja/IPLT)* is currently under construction for the city of Banda Aceh and surrounding areas.

2 Standards for Vegetated Leachfields

The following recommendations are based on the P.U. Building Code and National Standard for Septic Tank issued by *Badan Standarisasi Nasional Indonesia* code SNI 03-2398-2000 (Planning Guideline for Designing Septic Tank - *Tata Cara Perencanaan Tangki Septik)*.

The SNI for leachfields refers only to non-vegetated leachfields. These guidelines strongly recommend that leachfields be vegetated due to nutrient cycles in the tropics (refer to chapter above)

The proposed standard for the size of a leachfield (10 sq/m per 5 PE) is based on peak inflows of 200 l / hr. This requires a maximum infiltration rate of 20l/sqm/hr. The SNI recommends a minimum of 8.33 sq/m for 5 PE.

<u>Design Recommendation</u>

DIMENSIONS

- Proposed standard is 10sq/m x 75cm deep per standard household (5PE) or 2sq/m per 1PE

PIPING

- Leachfield pipes should have a diameter of 100mm (3")
- Leachfield pipe must be drilled with 8mm holes (or slots) according to a pattern which ensures even distribution of wastewater throughout the leachfield. The end of the pipe is closed with a cap.
- Leachfield pipes should be laid level or with only a very slight slope – Important: The pattern of holes or slots must be such that they evenly distribute water, the pattern will differ for horizontal or slightly sloped perforated pipes.
- Inspection pipes (100mm or 3") rising from the perforated pipe to 10cm above ground and closed with a cap, installed every 2.5m provide access for maintenance.

FILL MATERIAL – GRAVEL AND SAND MEDIUM

- Minimum 20cm gravel beneath the perforated leach pipe. The actual height of the perforated pipe is dictated by height of the outflow from the septic tank.
- Minimum 20cm gravel above the perforated leach pipe.
- Minimum 30cm clean builder's sand (pasir cor) is laid on top of the gravel.
- Gravel size is between 20-40mm – clean, crushed road base or hard limestone.
- *No soil is allowed in leachfields.* Soil will cause blockages
- *No palm fiber (ijuk) is allowed in leachfields.* Ijuk causes blockages.
- Plants are planted into the sand. They must be watered carefully (to avoid scouring the sand) to keep them alive until roots reach wastewater. Once the garden is established, rainwater will not damage the sand layer.
- Overland flows during heavy rains will damage the sand layer. Overland flows must be prevented from entering the leachfield - depends on site conditions, where necessary, a low wall or mound should be constructed around the leachfield.

LOCATION

- Leachfields present a threat of contamination to nearby wells. Leachfields should therefore be kept as far as practicable from shallow wells, and where possible they should be installed downstream of water sources.
- The P.U. / BRR Building Code for Aceh and Nias specifies that treatment systems with septic tank and leachfields should have a minimum distance to a shallow well of 10 m.
- Ideally, especially in very high water tables, vegetated leachfields should be installed in a mound above ground – i.e. a *Mounded* Leachfield. Therefore, house levels should elevated to allow enough slope for wastewater flows. Where houses are not raised leachfields must be installed below ground. Vegetated leachfields installed below ground may be subject to saturation or flooding when water tables are high. Although this is definitely considered sub-optimal, a 10sq/m vegetated leachfield is nevertheless considered far preferable to a conventional soak-pit.
- Leachfield gardens will be damaged by overland flows during heavy rains. If, because of the location, leachfields or wetlands are subjected to overland flows construct a low wall or mound, 10cm high, to deflect overland flows around the garden.
- If the house plot is unfenced a fence, wooden stakes and wire-mesh or split bamboo, will be required around the garden, to protect it from livestock eg. goats, cows, buffalo.

SPECIFICATIONS for PLANTS for VEGETATED LEACHFIELDS

In vegetated leachfields, plants are the 'machine', which 'drives' the treatment process. Treatment gardens – leachfields as well as subsurface flow wetlands - should be densely planted with moisture and nutrient-loving (i.e. fast-growing) plants. Plants of different species will facilitate more efficient treatment – different species take up nutrients at different rates.

Two fast growing plants are recommended as the basis for *domestic*, on-site treatment gardens i.e. leachfields & wetlands.

- **Vetiver Grass** (*Vetiver zizanioides)* - massive root system - shown to be effective in liquid waste treatment. Vetiver grass is available locally or it can be purchased in large quantities from farmers in Garut in Java.
- **Bananas**, the world's largest herbaceous plant, take-up large quantities of macro-nutrients (esp. potassium and nitrogen) and they can evapotranspire significant amounts of water. Banana 'suckers' may be purchased locally.
- **Other plants** may be used – generally, any plant, shrub or small tree, which enjoys high moisture and nutrient levels.

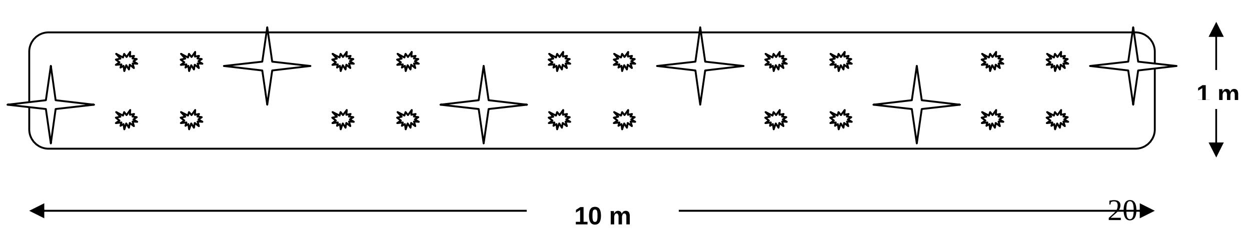
PLANTING STANDARD – 10 SQUARE METRE, VEGETATED LEACHFIELD

- **6 x healthy banana suckers**, 1m tall, of popular variety
- To be planted according to the Planting Diagram below ie. At 2m intervals, offset from the centre line
- **20 x clumps* of vetiver grass** - *Vetiver zizanioides* - Akar Wangi in Indonesian

* A **clump** is defined as a small cluster of 2-5 living shoots with roots attached

Banana **Vetiver grass**

PLANTING DIAGRAM

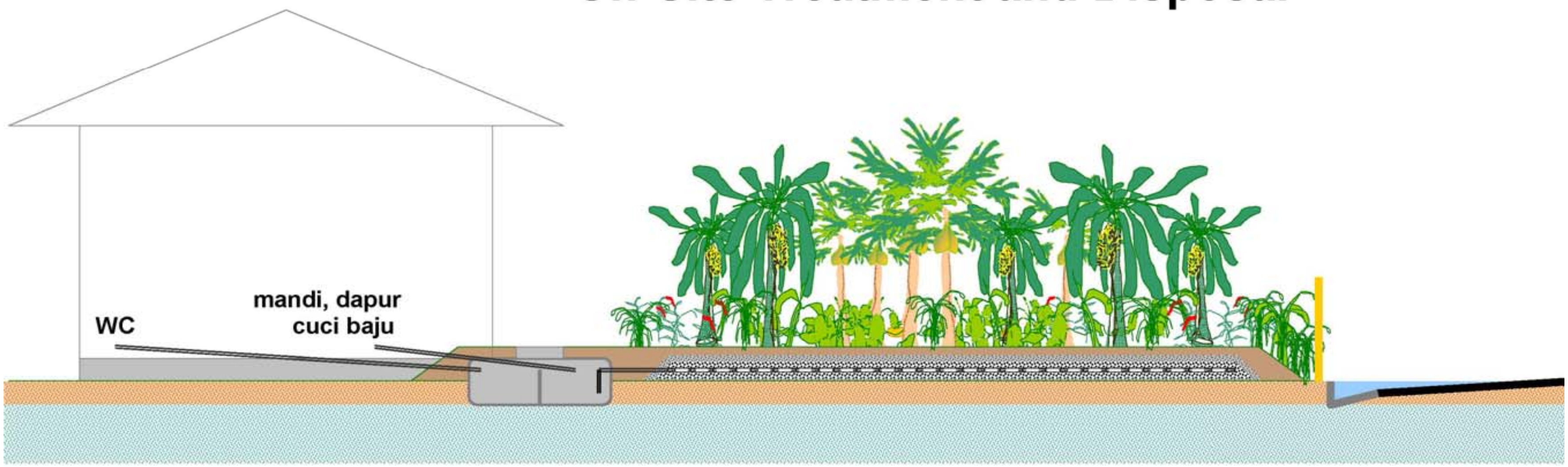


Prefabricated Horizontal **Concrete Septic Tank +** above-ground **Vegetated Leachfield**

IMPORTANT! Sewage & Wastewater outlets from house are 50-80cm higher

Septic tank + Leachfield can be raised 50-80cm higher

On-Site Treatment and Disposal



Leachfield and septic tank are covered with a layer of soil

Raised or mounded **leachfield has** ***unsaturated*** **soil to process wastewater**

3 Standards for Subsurface Flow Wetlands (SSF)

There are no available SNI Standards for Subsurface Flow Wetlands.

Design Recommendations

Subsurface flow wetlands require a vegetated leachfield or *surface* flow wetland/pond for final disposal. The many natural ponds and wetlands in tsunami-affected Aceh, if maintained in a natural condition, are ideally suited to receive secondary-treated wastewater from surrounding housing settlements.

DIMENSIONS

Proposed dimensions for on-site, subsurface flow wetlands depend on the method of final disposal.

- If combined with a *vegetated leachfield for final treatment and disposal*
  - **SSF wetland 4sq/m x 75cm deep** (per household 5 PE) plus
  - **Vegetated leachfield 6 sq/m x 75 cm deep**

- If combined with *disposal into a surface flow wetland*
  - **SSF wetland 8 sq/m x 75 cm deep** (per household 5 PE)

LINING MATERIAL

A subsurface flow wetland relies on a waterproof liner remaining watertight for a minimum of 20 years.

- Concrete wetland tanks produced on-site are an option where budgets allow, although these will encounter the same installation difficulties in Aceh as concrete septic tanks due to high water tables. The concrete should conform to SKSNI S-04-1989-F.
- Properly designed and manufactured fibreglass tanks are an option. These may be ordered locally.
- Strong plastic membranes are options. However, material has to be selected carefully. These guidelines recommend: High Density Polyethylene (HDPE), thickness 1 mm, with a density of 0.94 gr/cu/cm.
  Material should come in sufficient width to avoid the necessity for joins.
- Clay liners are also an option.

FILL MATERIAL – GRAVEL AND SAND MEDIUM

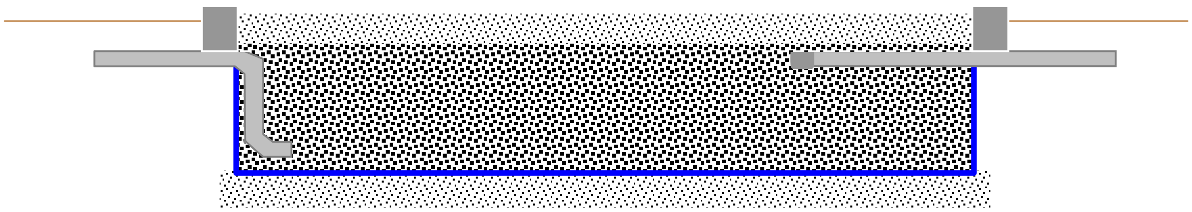
Fill material depends to some extent on the watertight structure or liner material. If concrete, crushed gravel is recommended. Where fibreglass or a plastic liner are to be used, rounded river stones are recommended to prevent damage from sharp stones.

- Sub-layer 50-60cm gravel growing medium - round river stones or crushed gravel - diameter 15-25mm
- Top layer 15-25cm *clean*, builder's sand
- Lay an area of larger gravel/stones with diameter 50-80mm around the inlet pipe, to facilitate inflows and prevent clogging.

PIPING

- Pipes have a diameter of 100mm throughout the ssf wetland.

- Inflows enter the wetland 10cm above the bottom liner.
- The height of the outlet pipe sets the water level in the wetland. Outlet pipes will be a minimum of 25cm below the top of the wetland media.
- Outlet pipes must have minimum 5 cm gravel above, to prevent sand falling into the holes in the perforated pipe.
- For on-site systems, outlet pipes should be approximately one quarter the length of the wetland. Examples: If the wetland is 8m long it should have a 2m long, perforated outlet pipe. A 4m long wetland would have an outlet pipe 1m long.



SPECIFICATIONS for PLANTS for SUBSURFACE FLOW WETLANDS

For on-site SSF wetlands, same specifications apply as for vegetated leachfields.

However, where *communal* wetlands are constructed, rushes, reeds and cattails are recommended. These natural wetland plants are readily available. Bananas may also be grown in communal SSF wetlands as can several other food or forage plants i.e. chillies, papaya and elephant grass.

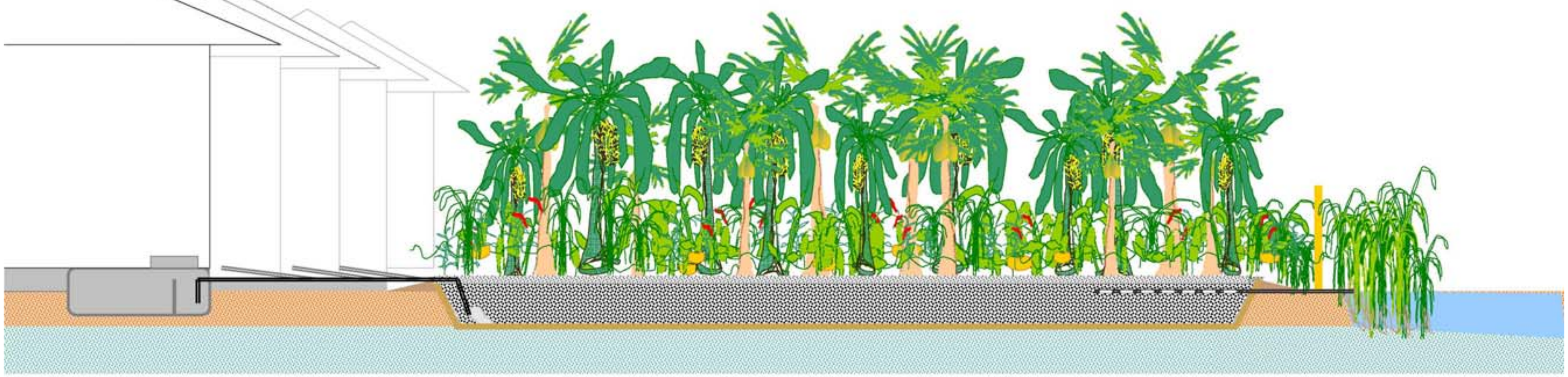
Septic Tank + Communal SSF Wetland

IMPORTANT! Sewage & Wastewater outlets from houses are raised 50-80cm to provide gravity flows to communal system, 50cm = 25m, 80cm = 40m

Communal Treatment and Disposal

2-20 houses

Can incorporate productive plants like bananas, or wetland plants like reeds, rushes and cattails, or vetiver grass or a combination of all.



Specification: 3sq/m/PE

SSF Wetland is lined with clay and bentonite

Disposal to adjacent pond or wetland